CFD MODEL OF THE INTERSTITIAL FLUID PRESSURE (IFP) IN REALISTIC TUMOR GEOMETRIES OF PERITONEAL METASTASES FROM OVARIAN CANCER

Mohammad Rahimi-Gorji[1,2*], Charlotte Debbaut[2], Margo Steuperaert[2], Christian Vanhove[3], Patrick Segers[2], Wim Ceelen[1]
[1]Laboratory for Experimental Surgery, Department of Surgery, Ghent University, Ghent, Belgium
[2]IBiTech – bioMMeda, Ghent University, Belgium
[3]Infinity Lab (IBiTech-MEDISIP), Ghent University, Belgium

Keyword(s): modeling of physiological systems

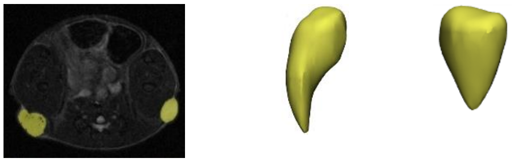
1. INTRODUCTION

Ovarian cancer (OC) is an important cause of death in women [1]. Over the past decades, intraperitoneal (IP) chemotherapy has been introduced in the treatment of stage III OC. The efficacy of IP chemotherapy is limited by elevated tumor tissue interstitial fluid pressure (IFP), which hampers convective drug transport from the peritoneal cavity into the tissue. Accurate, non-invasive measurements of tumor tissue IFP would allow to tailor IP therapy to the physical characteristics of the tumor [2]. Therefore, we aimed to estimate IFP in OC xenografts using a computational fluid dynamics (CFD) model based on dynamic contrast enhanced magnetic resonance imaging (DCE-MRI) data.

2. MATERIALS AND METHODS

Peritoneal metastases from human OC (SKOV-3 cell line) were created by subcutaneous injection in FOXn1-nu female athymic mice.

MRI imaging (Bruker- Infinity Lab-UGent) allowed obtaining the necessary anatomical information of the tumors. Two tumor geometries were reconstructed using Mimics Research software (Materialise, Belgium) (Figure 1). The resulting STL-files were imported in COMSOL Multiphysics (Inc., Burlington, VT) to setup both a steady state and transient mass transport model. Based on IP chemotherapy time, the transient model encompassed 1800 s, solved with a time step of 30 s. The CFD problem was solved by using Darcy's law, Starling's law and mass conservation equations [2]. As for boundary conditions, a fixed drug concentration was maintained (i.e. 0.8 mol/m³), mass source and reaction (using Starling's law) at the inlet boundary and the outlet pressure was set to 0 Pa [3].

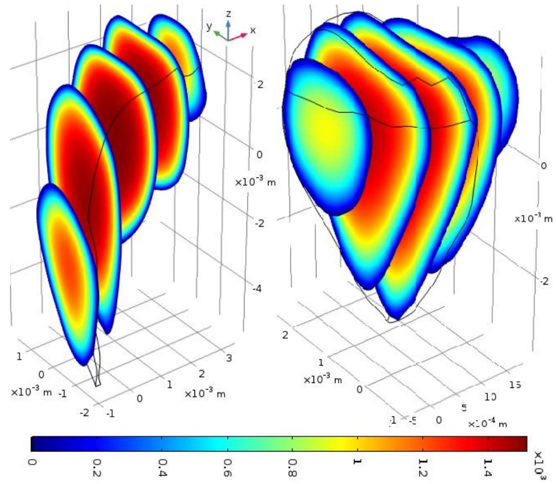


(a) (b) (c)

Figure 1: 3D reconstruction of realistic tumor geometries: (a) single slice of the MRI dataset, (b) 3D geometry of the right and (c) left tumor.

3. RESULTS AND DISCUSSION

Figure 2 displays the resulting 3D pressure distributions in the tumors. The maximal IFP values were 11.43 mmHg and 11.09 mmHg in the right and left tumor, respectively. Obviously, the IFP distribution is strongly dependent on the irregular tumor geometries. Consequently, the IFP in the central tumor regions is higher, while decreasing towards the peripheral regions. The model will be validated by comparison with invasive pressure measurements.



(a) Right tumor (b) Left tumor

Figure 2. Pressure distribution for double tumors.

References

[1] http://www.WHO.int/.

[2] Baxter, L., Jain, R. Transport of fluid and macromolecules in tumors. *Microvasc Research*, 37(1), 77–104, 1989.

[3] Steuperaert, M. et al. Mathematical modeling of intraperitoneal drug delivery. Drug Delivery, 24(1), 491–501, 2017.